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SUBSPACE-BASED OPTIMIZATION METHOD FOR RECONSTRUCTING 3-D SCATTERERS IN ANISOTROPIC LAMINATES

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This paper investigates the subspace-based optimization method (SOM) for reconstructing defects in the anisotropic laminates. Reconstruction of defects in such media, like planar composite panels applied in aeronautic and automotive industry, is greatly challenging to execute, due to the complexity in the anisotropy of materials and multi-layered structure [1]. The main advantage of SOM is to split the space of induced currents into mathematical deterministic and ambiguous subspaces, as opposed to physical radiating and non-radiating subspaces in the noise-free scenario and mathematically measurable and non-measurable in the noisy scenario [2-3]. The deterministic subspace is determined from the spectrum analysis, whereas the ambiguous subspace is calculated by an optimization method. This feature makes SOM fast convergent, robust against noise and the selection of the regularization parameter L that is used to split the space of induced currents [4-5]. This work extends the SOM to multi-layered anisotropic inverse scattering problems involving 3-D complex defects.

In this abstract, the detailed methodology for reconstructing defects in anisotropic multi-layered media is difficult to discuss thoroughly. Therefore, the effectiveness of this approach is illustrated via numerical experiments only.

For the numerical experiments, a cubic region of interest (ROI) of side 0.3λ (λ is the wavelength of incident waves in the free space) located at (0, 0, -0.35λ) is within an anisotropic medium characterized with relative permittivity diag[2 + i0.3, 3 + i0.1, 3 + i0.1] along its principal axes and 60 degrees rotation angle between its principal axes and the global axes. The measurement setup employs 100 ideal dipoles oriented in the x, y, and z directions as transmitters and 100 receivers placed at the same locations as the ones of the transmitters. They are distributed uniformly on a square grid of side 5λ with d = 0.05λ and H = 0.35λ, as shown in Fig. 1. The operating frequency of transmitters is 3 GHz. The ROI is discretized into 6×6×6 voxels. The parameter L is chosen as 37.

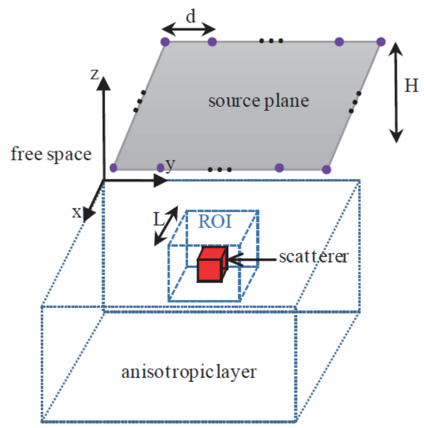

Figure 1. Geometry of the 3D scattering inverse problem

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The first numerical experiment deals with an eight-voxel scatterer centered at (0, 0, -0.325λ), with the material of air. In the ROI, the scatterer occupies voxels (3:4, 3:4, 4:5), as shown in Fig. 2(a). It is assumed that the measurements are noiseless. Fig. 2 shows the 3-D imaging comparison of exact defects and those calculated by the SOM imaging approach. It can be seen that this approach is capable of detecting the location and size of the scatterer. More experiments including the noisy scenario will be shown in the full paper.

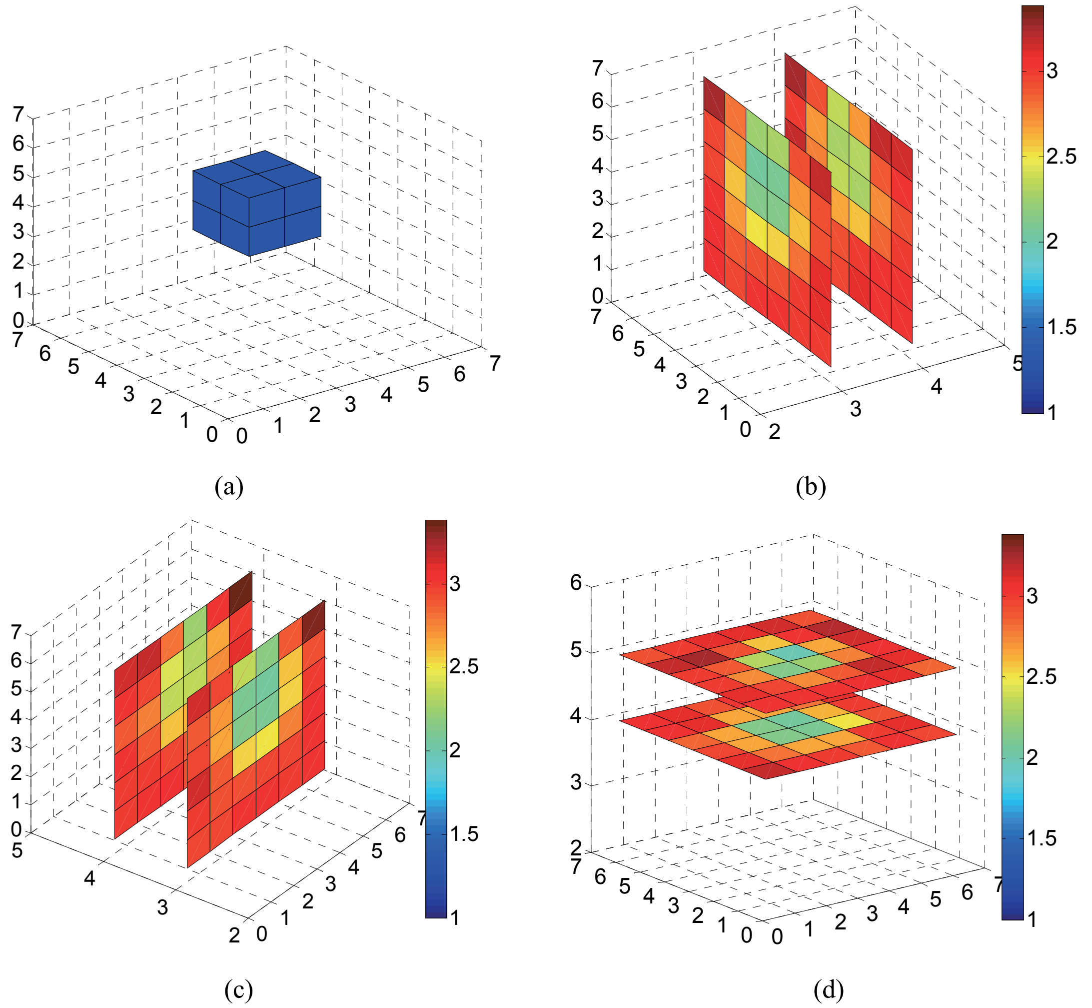

Figure 2. Comparison of the exact profile and reconstructed permittivity ε_{33} profile. Fig. (a) refers to exact location of the scatterer. Figs. (b), (c), and (d) refer to reconstructed permittivity profile on xz, yz, xy surfaces, respectively

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